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This report presents a method and apparatus for evaluating potential heat of solid wastes. Even wastes with low or negative heat content values can be determined by the described method.

17. Key Words and Document Analysis. 17a. Descriptors

*Solid waste disposal,
*Incinerators,
*Enthalpy,
*Heat measurement,
Heat of combustion, Experimental design.
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# LABORATORY PROCEDURE FOR THE POTENTIAL HEAT DETERMINATION IN SOLID WASTES

A Division of Research and Development
Open-File Report (RS-03-68-17)

written by
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U.S. ENVIRONMENTAL PROTECTION AGENCY
Solid Waste Management Office
1971

In publishing an analytical method which employs specific brands of laboratory supplies and instrumentation, the Environmental Protection Agency does not imply that other commerical products could not be utilized with appropriate modifications in the procedure.

This method is meant to be used in conjunction with the "Laboratory Procedure for the Total Heat of Combustion Determination in Solid Wastes" and was written as such.

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## DISCUSSION

Not all solid waste samples with about the same total heat content (enthalpy, or heat of combustion value) will have about the same ease to ignite or the same degree of combustibility. The readily available heat content of a solid waste sample or its "potential heat" could be an important criteria for evaluating the efficiency of an incinerator or for measuring the usefulness of incinerator residue.

Potential heat is not a new concept. The construction industries have long been interested in the potential release of heat of materials involved in building fires.[1] In the construction industries, potential heat is defined as "the difference between the heat of combustion of a representative sample of the material and the heat of combustion of any residue remaining after exposure to a simulated standard fire, using combustion calorimetric techniques." Conditions for a standard fire cannot be assimulated when dealing with incinerators. However, since a combustion aid is employed in the method for total heat of combustion values[2], the ease at which solid waste materials ignite and burn to completion can be measured by applying the same calorimetric techniques except omitting the combustion aid and allowing only the flash heat of the ignition wire to ignite the sample.

The method, presented herein, describes the modifications in the total heat of combustion procedure which are necessary for obtaining the potential heat of combustion values in incinerator residue and fly ash samples. Other types* of solid waste materials usually do not have a potential heat value. Some incinerator residue and fly ash samples have negative potential heat values. Such samples are high in carbonates which absorb heat upon decomposing (endothermic reaction).

Having the total and potential heat values, the analyst can obtain the "residual" heat content of the sample. Residual heat content is defined as the total heat content minus the potential heat content. Residual heat value represents the heat content of a residue or fly ash sample not easily obtainable and would probably exist no matter how efficient a particular incinerator is operated.

## APPARATUS

The apparatus for this method is no different than those described in the procedure for total heat of combustion determination; therefore, the list of apparatus is not repeated here.

## REAGENTS

The chemical requirements and the preparation of reagents for this

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*Types of solid waste in this method refer to only solid samples (domestic origin) as: raw refuse, incinerator fly ash, incinerator residue, and compost.

method are no different than those described in the procedure for total heat of combustion determination; therefore, the information is not repeated here. Benzoic acid, although not used in this method as a combustion aid, is required in standardizing the calorimeter.

## SAFETY PRECAUTIONS

The analyst is referred to the Parr Company's manual No. 130, page 9, "Hazards of Operation".

## SAMPLE PREPARATION

The techniques of sample preparation are the same as those outlined in the procedure for total heat of combustion determination. Since this method must be employed in conjunction with the procedure for total heat of combustion determination, instructions for sample preparation are not duplicated here.

## PROCEDURE

This procedure applies to all solid waste materials which normally require a combustion aid in the determination of total heat content. Since the mechanics are about the same as those outlined in the procedure for total heat content, except no addition of a combustion aid, the details of the procedure are not repeated here. However, the analyst must take note that duplicate results may not agree if the sample partly ignites one time and not the next. This

disagreement of results very seldom occurs; but, if it does happen, the analysis should be repeated until the sample ignites again. Lack of ignition can be detected by observing that the temperature rise is very slight and the answer is around zero. The one mechanical operation that can cause a sample not to ignite when it should is the position of the ignition wire. This ignition wire must be installed, as instructed, close to the sample but not touching the sides of the sample container or the sample itself. The same restrictions upon sample portions apply for both methods. Since a combustion aid is not used in this method, the sample is spread evenly on the bottom of the sample container.

## STANDARDIZATION

The term "standardization" denotes the determination of the energy equivalent or water equivalent factor (W) of the system. (See Parr Manual No. 130, page 23.) Benzoic acid, primary standard with calorific value known, is the material used to determine the W factor. The benzoic acid is analyzed in the manner described under "Procedure" in the method for total heat content.

## CALCULATIONS

### Total Heat Content

The formula for computing total heat content of a sample is described in the method for total heat of combustion determination.

### Potential Heat Content

The formula for computing potential heat content of

a sample is the same as the formula for total heat content except the "$e_4$" term, which is the heat content of the combustion aid, is omitted.

Residual Heat Content

Compute the residual heat content of a sample by substituting in the following equation:

$$\Delta H_{c(R)} = \Delta H_{c(t)} - \Delta H_{c(P)}$$

where:

$\Delta H_{c(R)}$ = residual heat of combustion of sample in calories per gram or in British thermal units per pound (Btu/#)*

$\Delta H_{c(t)}$ = total heat of combustion of sample as determined by the total heat of combustion method used in conjunction with this method

$\Delta H_{c(P)}$ = potential heat of combustion of sample as determined by method described herein

## METHOD EVALUATION

This method can analyze solid wastes materials with low or even negative potential heat content values. Duplicate observations upon the same sample will agree, 95% of the time, within about 25.8 to 144 Btu/# depending upon the type of sample and whether some sample combustion takes place or not (Table 1).

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*NOTE: Value must be expressed in same units throughout the formula.

TABLE 1

POOLED STANDARD DEVIATION[a] OF THE POTENTIAL

Btu/# DETERMINATION ON SOLID WASTES

| Type of Sample | Number of Samples | Potential Btu/# Duplicate Observations | Btu/# Range |
|---|---|---|---|
| Residue (Fines)[b] | 9 | 32.0[c] | 597 to 2580 |
| Residue (Fines) | 8 | 13.8 | -24.1 to 25.9 |
| Fly Ash | 13 | 9.3 | -35.3 to 12.3 |

a. A variance estimate can be calculated from the duplicate (or triplicate) set of observations for each sample. The pooled variance is essentially an average of all such estimates for samples of a given type. It is assumed that a single underlying variance exists for all samples of a given type. The pooled variance is then the best estimate of this underlying variance. The pooled standard deviation is the square root of the pooled variance and is used to estimate the underlying standard deviation.

b. "Fines" are materials remaining after most of the readily combustible substances have been removed by manual sorting. This material passed through a ½-inch sieve.

c. The absolute value of the difference between duplicated observations should not exceed 1.96 $(\sqrt{2})(s)$, confidence interval, or 144 Btu/#, more than 5% of the time. The covariance between the duplicated observations was ignored.

Although a temperature rise was always observed in these tests, a lowering of initial temperature is very possible. Such as, a sample high in carbonates, which decompose easily, can produce a negative temperature change when the carbonates decompose upon being heated by the ignition wire. To ensure good precision, samples should be prepared in the same manner as indicated in the total heat content method.


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